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FINAL REPORT

AFOSR-81-0228

UNIVERSITY OF RHODE ISLAND

P. C. Schultz

1981 GORDON CONFERENCE ON GLASS

30 April 1982

~~CONFIDENTIAL~~

6 MAY 1982

To: Dr. D. Ulrich ✓  
cc: Dr. C. Cruickshank  
Prof. C. Moynihan  
From: P. C. Schultz *PC*  
Subject: AFOSR Final Report, 1981 Gordon Conference on Glass  
(AFOSR Grant # 81-0228)  
Date: April 30, 1982

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The subject conference was held August 3-7, 1981 at Plymouth State College, Plymouth, New Hampshire and is briefly summarized in this report. Twenty-two invited speakers presented their recent and unpublished research results on fluoride glasses, novel glasses (including gels) and strength behavior to 110 conferees (a record number for the glass conference). Considerable constructive discussion ensued between speakers and conferees - all felt the meeting was a great technical success. In addition, informal poster sessions were held allowing any conferee to present up-to-date results on any glass science subject. Attached are the complete program for both invited and poster papers. Some highlights of the invited papers are summarized below:

#### Fluoride Glasses

Poulain (Univ. Rennes) reviewed the field and presented new glass systems found (eg. Zr-free glasses based on Th, Al, Y, Ba and Sc, Y, Ba) which show excellent durability and IR transmission. He proposed a general glass-forming rule based on ionic field strength,  $F$ , where fluoride glasses form if  $2.5 < \frac{\sum F_{\text{cations}}}{\sum F_{\text{anions}}} < 10$ .

Drexhage (RADC, Hanscom AFB) showed IR properties of Hf and Zr fluoride glasses are unaffected by melt atmosphere (inert or reactive) provided they are formed under controlled conditions; critical factor is use of pure, dry fluoride batch materials. Material dispersion data were given indicating 1 GHz·km bandwidth should be achievable at minimum loss  $\lambda$  despite zero dispersion occurring at much shorter  $\lambda$ .

Manabe (NTT-Ibaraki) covered critical physical properties for Zr-Ba-Gd fluoride glasses for IR fibers ( $n_D$ ,  $\beta$ ,  $d^2n/d\lambda^2$ , Rayleigh scattering,  $T_g$ ) and described preparation of all-glass optical waveguides ~4 meters long with 82 dB/km at 2.6  $\mu$ m (a record low loss at the time). He calculated as little as 10 ppb OH impurity would contribute 100 dB/km at 3  $\mu$ m.

April 30, 1982

### Novel Glasses

Nassau (BTL) presented data on rapidly quenched glasses of traditional crystalline compounds such as  $\text{BaTiO}_3$ . In general, crystal properties are better than glass analogs. He and Kriedl predicted rapidly quenched nonoxide glasses may have much higher conductivities than oxide glasses, since electrical properties of latter are limited by "oxygen cage".

Hench (Univ. Fla.) showed that a novel  $\text{CO}_2$  reaction with 30 mole% sodium silicate gels during the gelling/drying steps apparently leads to alkali carbonate formation. The latter greatly aids sintering characteristics, leading to clear glasses between  $450\text{--}550^\circ\text{C}$ , by keeping pores open longer during heat treatment thereby facilitating outgassing. Interestingly, gel-derived glasses weather faster than melted glasses.

Sakka (Univ. Mie) provided gel processing/property details for films, coatings, fibers prepared in  $\text{SiO}_2$ ,  $\text{TiO}_2\text{--SiO}_2$ ,  $\text{ZrO}_2\text{--SiO}_2$  glass systems. Most properties similar to melted versions, but strength is considerably lower (~50%).

### Strength

Freiman (NBS) reviewed crack growth theory and showed that any "water-like" molecules (eg, hydrazine, formamide) behave similar to hydroxyls in greatly accelerating crack tip growth velocity.

Mecholsky (Sandia) showed that fracture toughness can be greatly improved by presence of spherical-like inclusions in the glassy matrix which tend to split stresses at propagating crack tips to values below critical levels. Stress intensity factor  $K_{IC}$  was shown to increase linearly with vol %  $\text{Al}_2\text{O}_3$  particles in glass and can be peaked with appropriate surface area/vol. values for phase separated glasses.

France (British Telecom) discussed fatigue behavior of sodium borosilicate glass fiber optical waveguides. Both strength and fatigue properties are approximately equal to fused silica values (presented by Helfenstine, Corning) for long gauge length fibers (> 50 meters) when  $\text{ZrO}_2$  and  $\text{Al}_2\text{O}_3$  additions are made to the cladding region.

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GORDON RESEARCH CONFERENCES

GLASS

August 3 - 7, 1981

Plymouth State College - North  
Plymouth, New Hampshire

Peter K. Schultz, Chairman  
Cornelius Moynihan, Cochairman

*P. Schultz*  
*notes*  
*attached*

Monday, August 3

MORNING SESSION - FLUORIDE GLASSES

M. Robinson, Chairman  
Hughes Research Labs, California

Fluoride and Polynalide Glasses

Marcel Poulain  
Univ. Rennes, France

Optical Properties of Multicomponent  
Fluoride Glasses

Martin Dreshage  
Rome Air. Dev. Ctr., USA

Fabrication Technique and Trans-  
mission Characteristics of the  
Fluoride Glass Fiber

Toyotaka Manabe  
NTT Ibaraki Lab, Japan

EVENING SESSION - OXYNITRIDE GLASSES

T. Maceolo, Chairman

Oxynitride Glasses

Ronald E. Loehman  
SRI International, USA

Effect of Nitrogen on Physical  
Properties of  $MgO-Al_2O_3-SiO_2$  Glasses

Raja Wusirika  
Corning Glass Works, USA

Tuesday, August 4

MORNING SESSION - NOVEL GLASSES

G. Frischat, Chair  
Lehrstuhl Glas und Keramik  
Zehntnerstrasse, W. Germany

Rapid Quench Glasses

Kurt Nassau  
BTL Murray Hill, USA

Techniques for Incorporation of  
Water into Silicate Glasses

Riger Bartholomew  
Corning Glass Works, USA

GLASSES FROM GELS

L. Klein, Chairman  
Rutgers Ceramics Dept.  
Piscataway, NJ

Glasses from Chemical Polymerization

Bulent Yoldas  
Westinghouse Electric Co., USA

EVENING SESSION

Potential Applications of Sol-Gel  
Processes

Ramon Puyane  
Battelle Geneva, Switzerland

Compositional Processing Effects  
on the Gel-to-Glass Conversion

C. Jeffrey Brinker  
Sandia Laboratories, USA

Wednesday, August 5

MORNING SESSION

S.P. Mukherjee, Chairman  
Battelle Memorial Inst., Ohio

Surface Behavior of Gel Glasses

Larry Hench  
University of Florida

Mechanism of Formation of Glass  
Fibers and Films through Sol-Gel  
Conversion of Alkoxides

Sumio Sakka  
Mie University, Japan

Composition, Quality and Purity  
of Densified Silicate Gel Glasses

Robert Shoup  
Corning Glass Works, USA

EVENING SESSION - STRENGTH OF GLASS

Crack Propagation and Stress  
Corrosion of Glass

Steven Fraiman  
National Bureau of Standards, USA

Role of Surface Energy in Mechanical  
Strength of Glass

Minoru Tomozawa  
Rensselaer Polytechnic Inst., USA

Thursday, August 6

MORNING SESSION

P. Gupta  
Owens Corning Fiberglass, Ohio

*Noteworthy Findings*  
Environmental Effects on Stress  
Corrosion

Herbert Richter  
Festkorpermechanik Inst., W. Germany

Fracture Toughness of Glasses and  
Glass-Ceramics

Jack Mecholsky  
Sandia Laboratories, USA

Dissolution Kinetics of Glass in  
Geologic Media

Hans Claasen  
U.S. Geological Survey, USA

Banquet Lecture: Global Tectonics,  
Volcanoes and the Depths of the  
Earth, Natural Glass Production  
and the Plagues of Egypt

Julian Goldsmith  
University of Chicago, USA

EVENING SESSION - Open Poster Session

Friday, August 7

Fatigue Behavior of Glass Fibers  
Used for Optical Communications  
(Includes Compound Glasses)

Paul France  
British Telecom Res. Labs, England

Fatigue Behavior of Doped Fused Silica  
Optical Waveguides

John Helfenstine  
Corning Glass Works, USA

## GORDON RESEARCH CONFERENCES

## GLASS

## POSTER SESSION

Thursday, August 6, 1981

<u>Author</u>	<u>Poster Paper Title</u>	<u>Room No.</u>
G.H. Frischat and C. Schrimpt	Preparation and Properties of N <sub>2</sub> -Containing Na <sub>2</sub> O-CaO-SiO <sub>2</sub> Glasses	205
P. R. Garnier	Foaming of Some Nitrogen Glasses by Exposure to Water Vapour	508
D. Gavin, R. Syed and C. Moynihan	Functional Form of Arrhenius Equation for Electrical Conductivity	519
Robert Hopper	Stochastic Theory of Scattering from Spinodal Structures	510
Lisa Klein and G.J. Garvey (D.Gallagher, T.Gallo, G. Mucci, J. Reed)	Fundamental Properties of the Sol-Gel Transition	
Richard Lehman and Victor Greenhut	Surface Crystal Formation During Acid Corrosion of P <sub>2</sub> O <sub>5</sub> Doped Lead Silicate Glasses	206 409
Akio Makishima	Preparation and Characterization of Oxynitride Glass With High Nitrogen Content	421
Shyma P. Mukherjee & W. Howard Lowdermilk	Single Layer Antireflection Films Deposited by the Sol-Gel Process	
K. Nassau	The Material Dispersion Zero in Infrared Optical Waveguide Materials	204
G. F. Neilson	Phase Separation of Sodium Silicate Glasses Prepared from Gel Precursors	219
Marcel Poulain	A Basic Topologic Equation: Application to Glasses	501
E.M. Rabinovich, J.W. Johnson, Jr., J.B. MacChesney and E.M. Vogel	Preparation of Transparent High-Silica Glass Articles by Sol-Gel Process with Sintering	217 .
W. Vogel W. Holand	Nucleation and Crystallization Kinetics of an MgO-Al <sub>2</sub> O <sub>3</sub> -SiO <sub>2</sub> Base Glass with Different Dopants	306
David Ziegler and C.A. Angell	BiCl <sub>3</sub> -KCl Glasses	